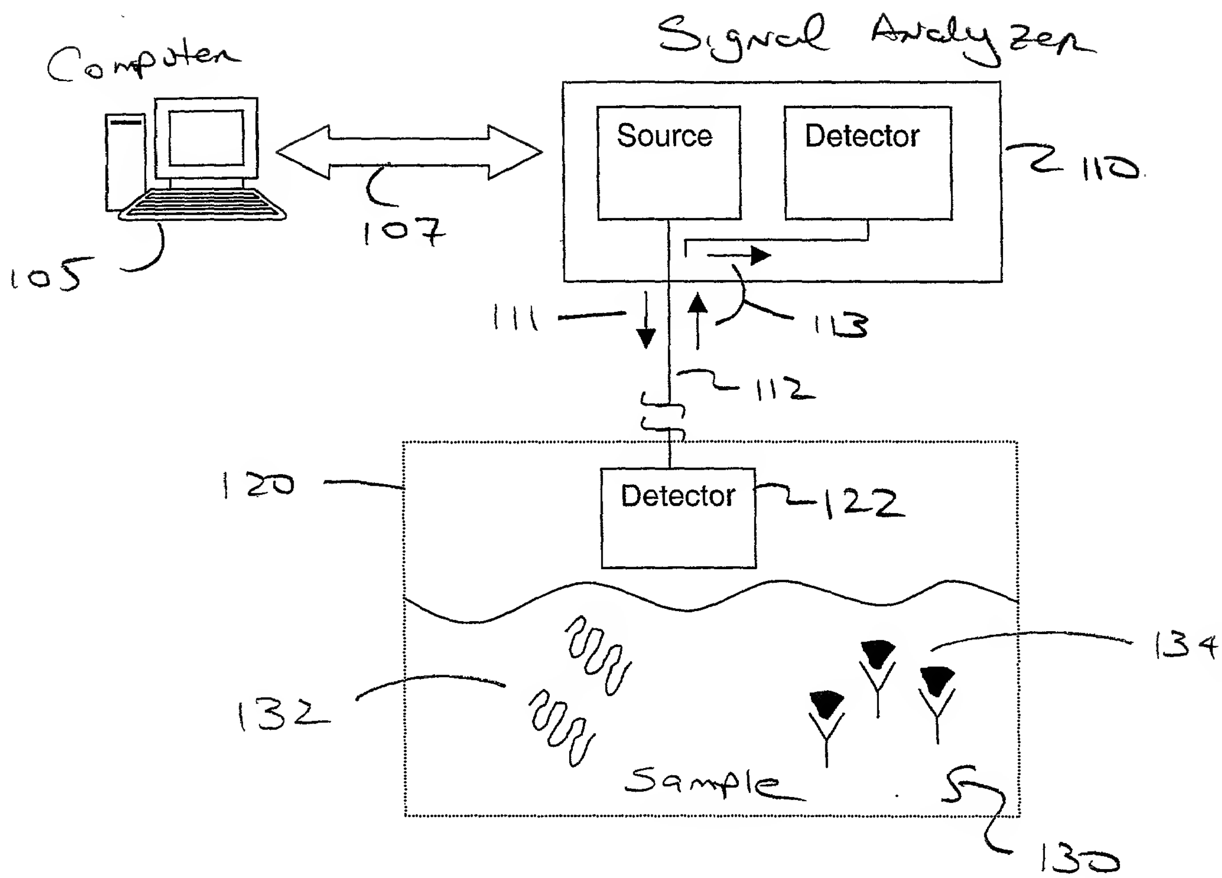
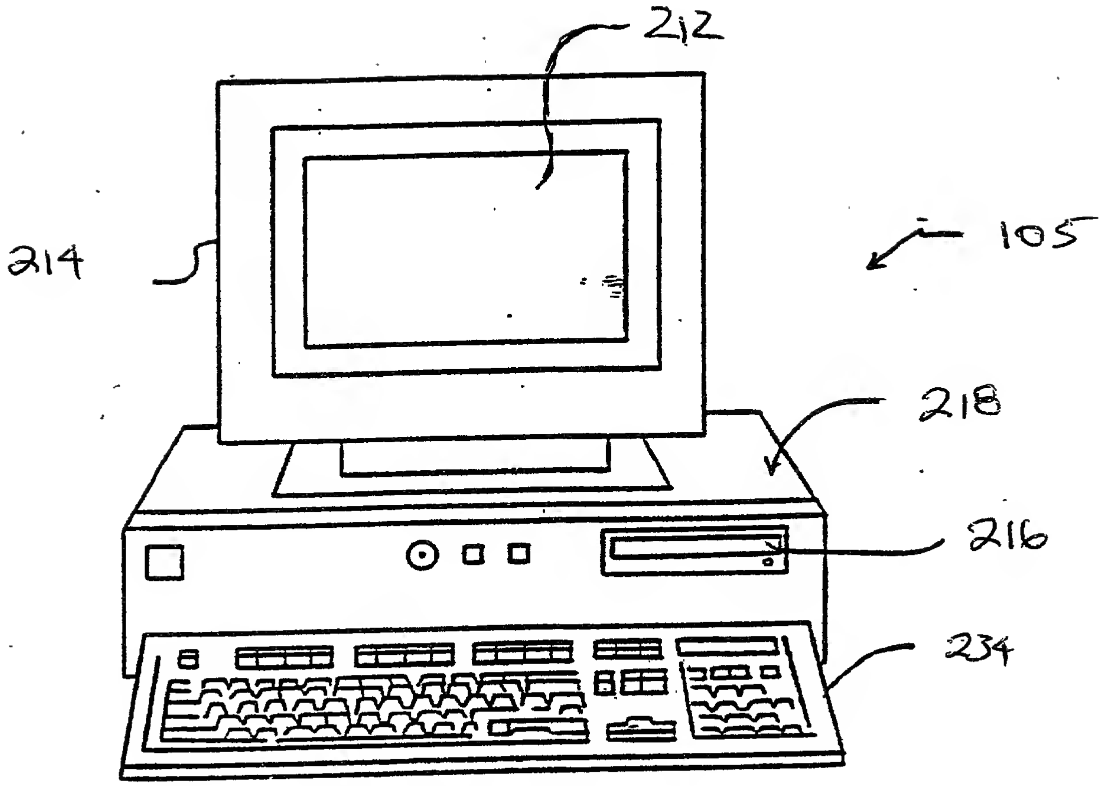
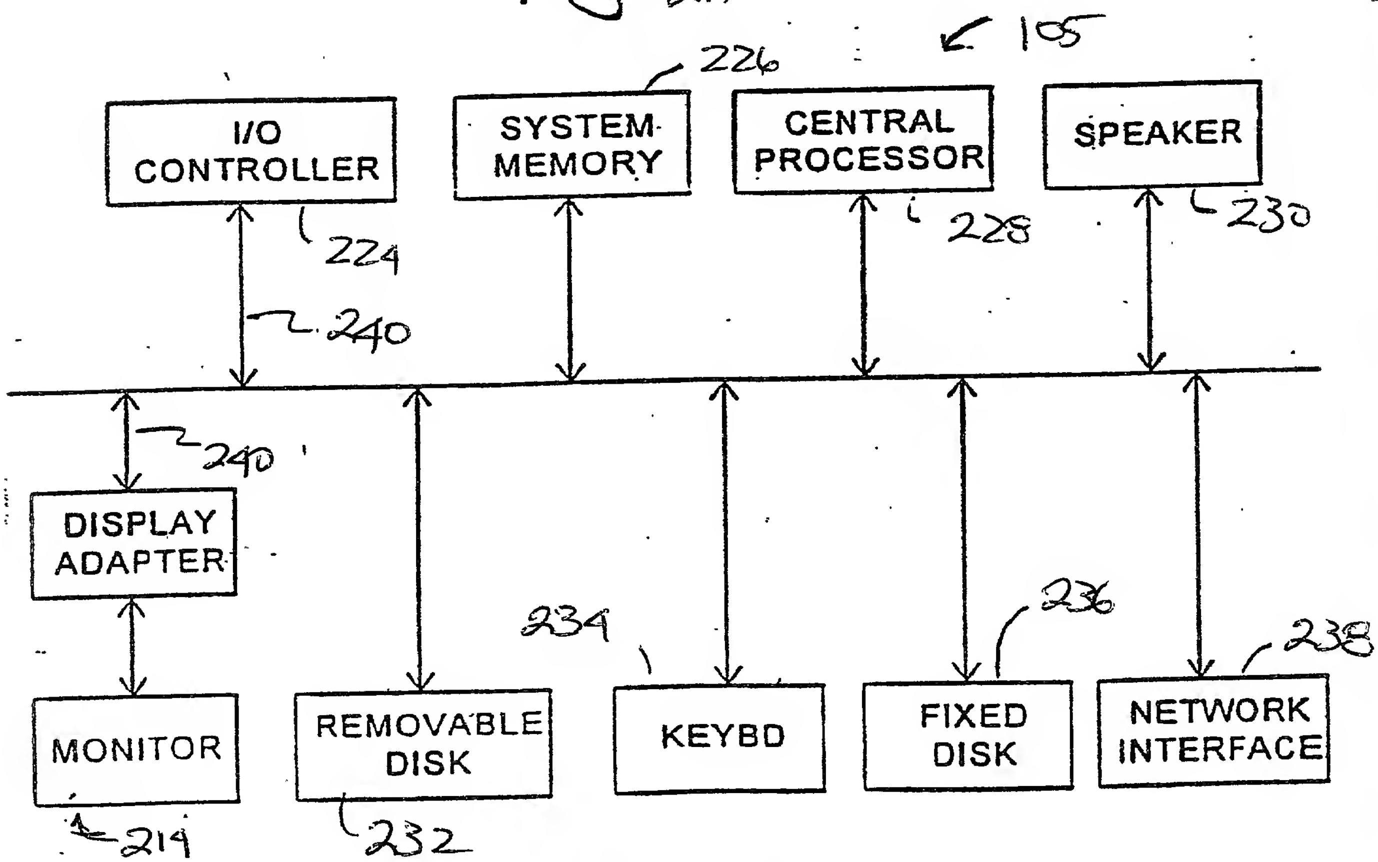

Computer
Signal Analyzer
Source
Detector
110
105
107
111
113
112
120
Detector
122
134
132
Sample
130

Fig 1



212
214
105
218
216
234

Fig 2A



105
226
I/O CONTROLLER
SYSTEM MEMORY
CENTRAL PROCESSOR
SPEAKER
224
228
230
240
240
DISPLAY ADAPTER
234
236
238
MONITOR
REMOVABLE DISK
KEYBD
FIXED DISK
NETWORK INTERFACE
214
232

FIG. 2B

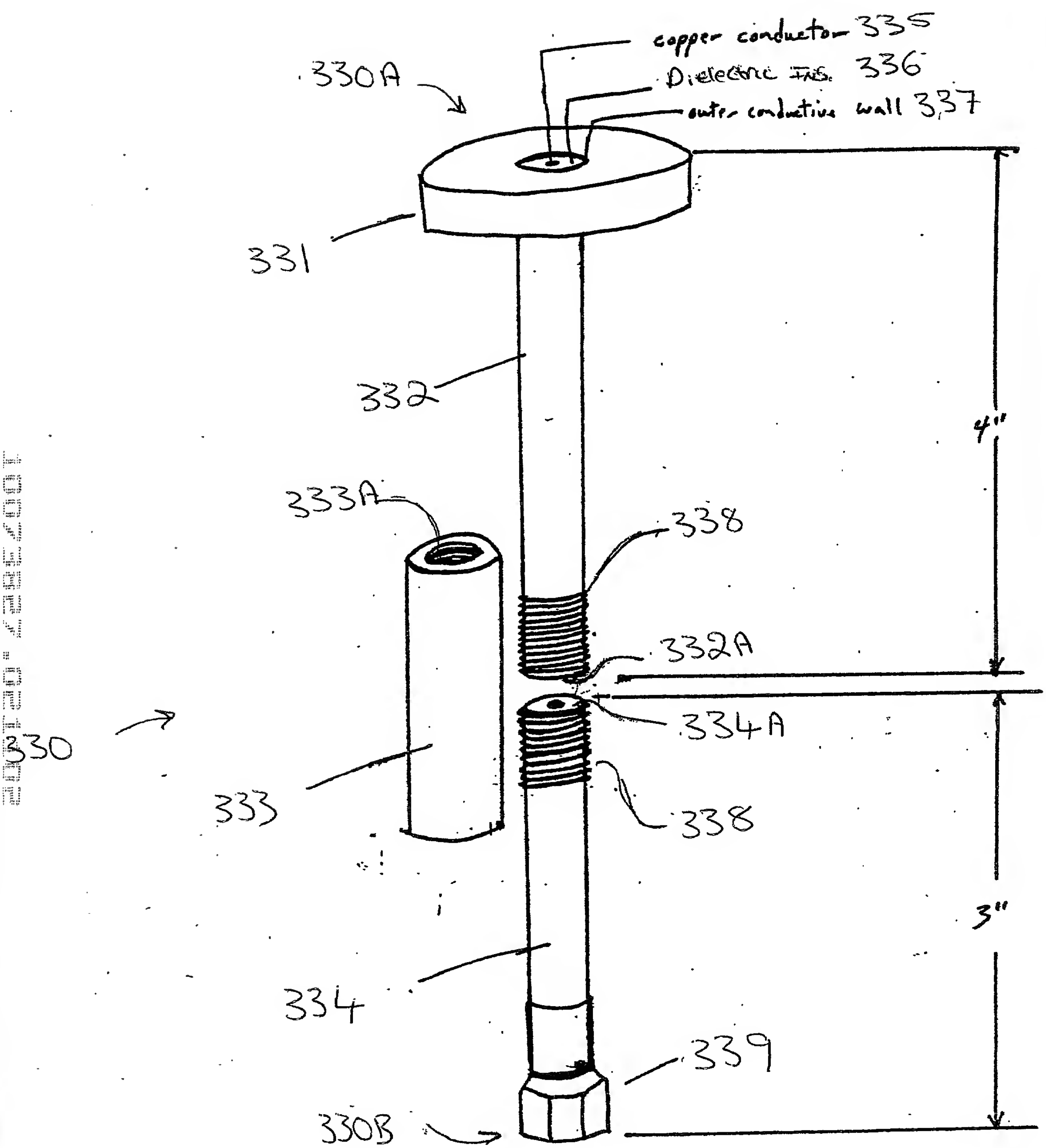

copper conductor 335
Dielectric INS. 336
outer conductive wall 337
330A
331
332
4"
333A
338
332A
334A
330
333
338
3"
334
339
330B

Fig. 3A

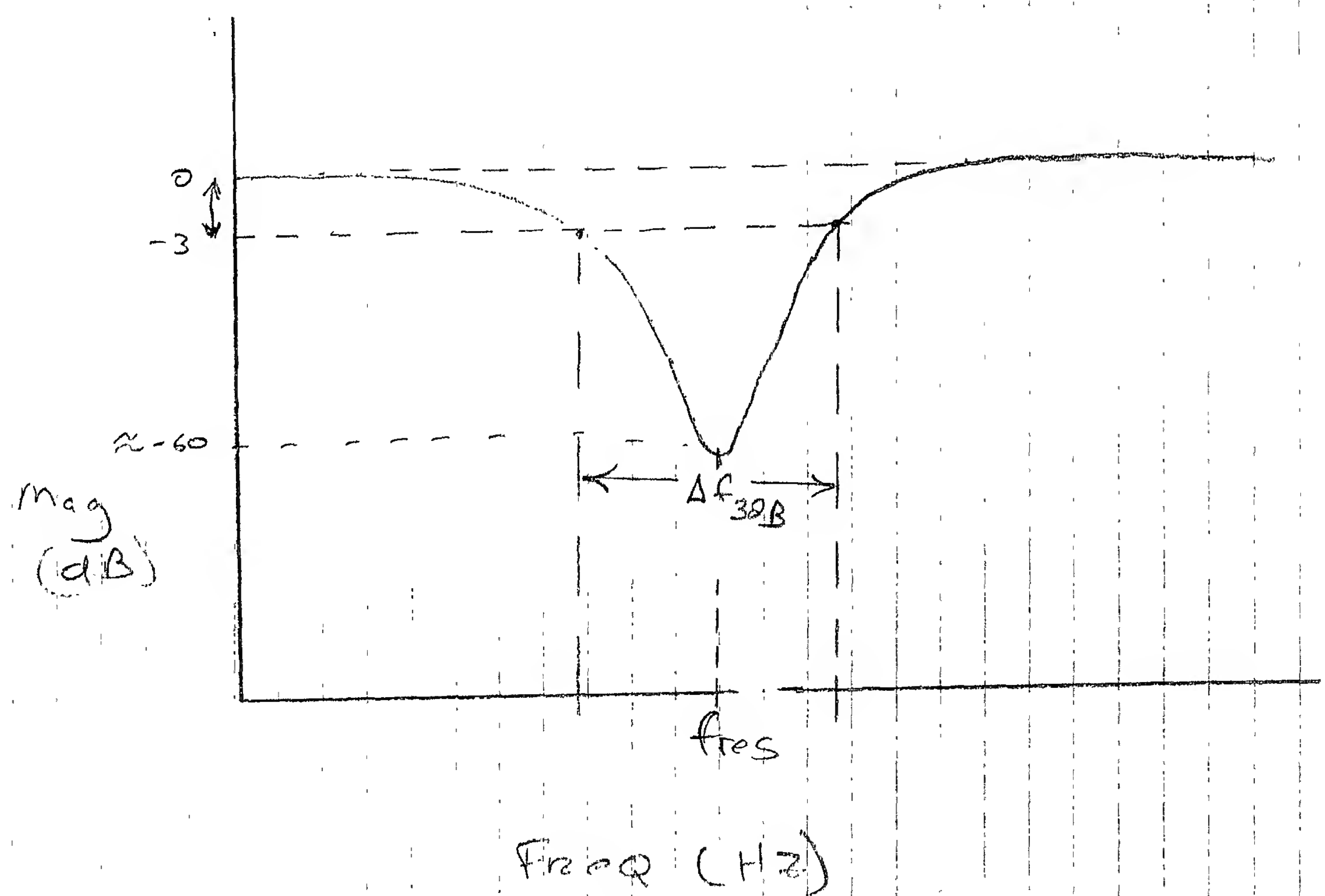
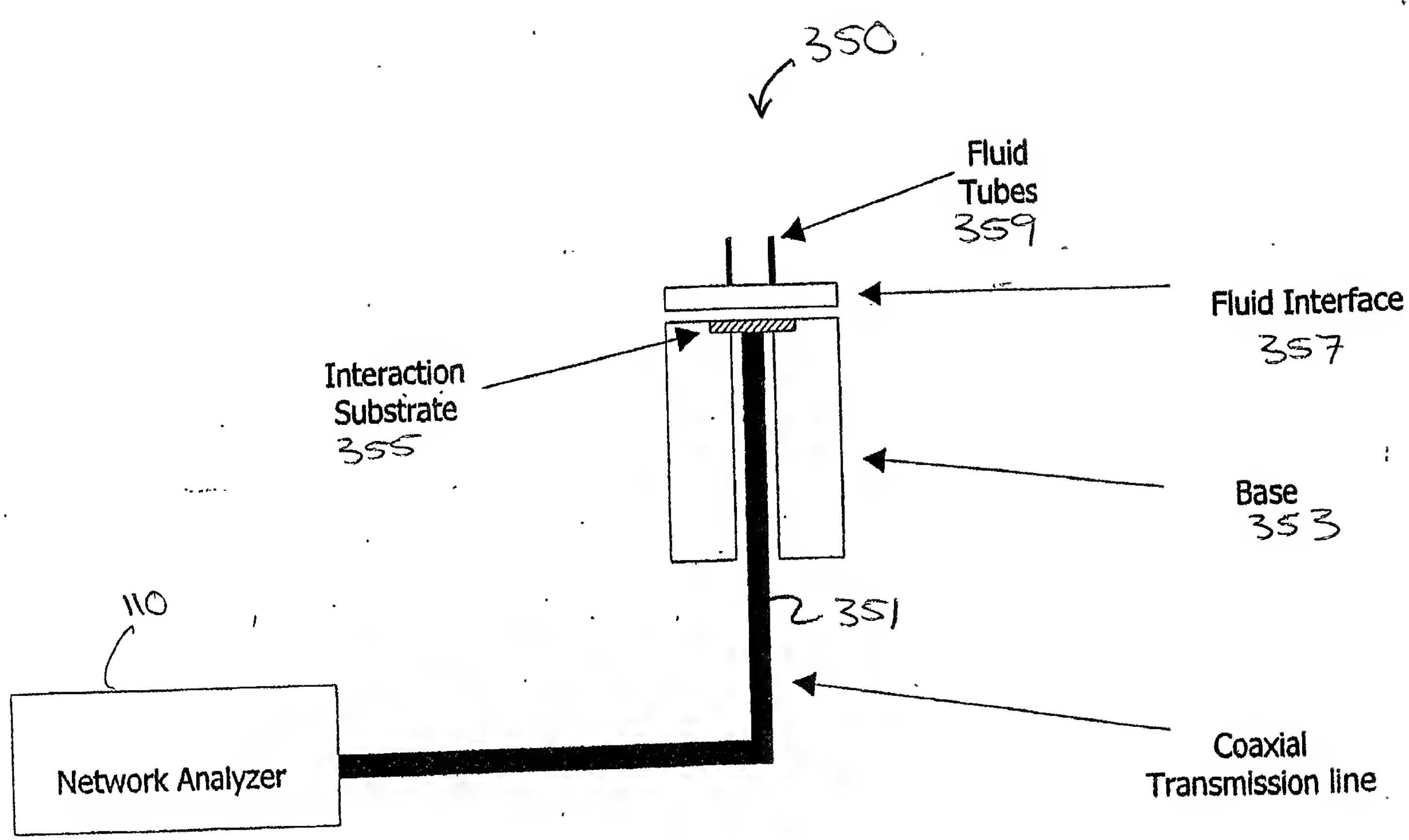


Fig. 3B



350
Fluid
Tubes
359
Fluid Interface
357
Interaction
Substrate
355
Base
353
351
110
Network Analyzer
Coaxial
Transmission line

Fig. 3C

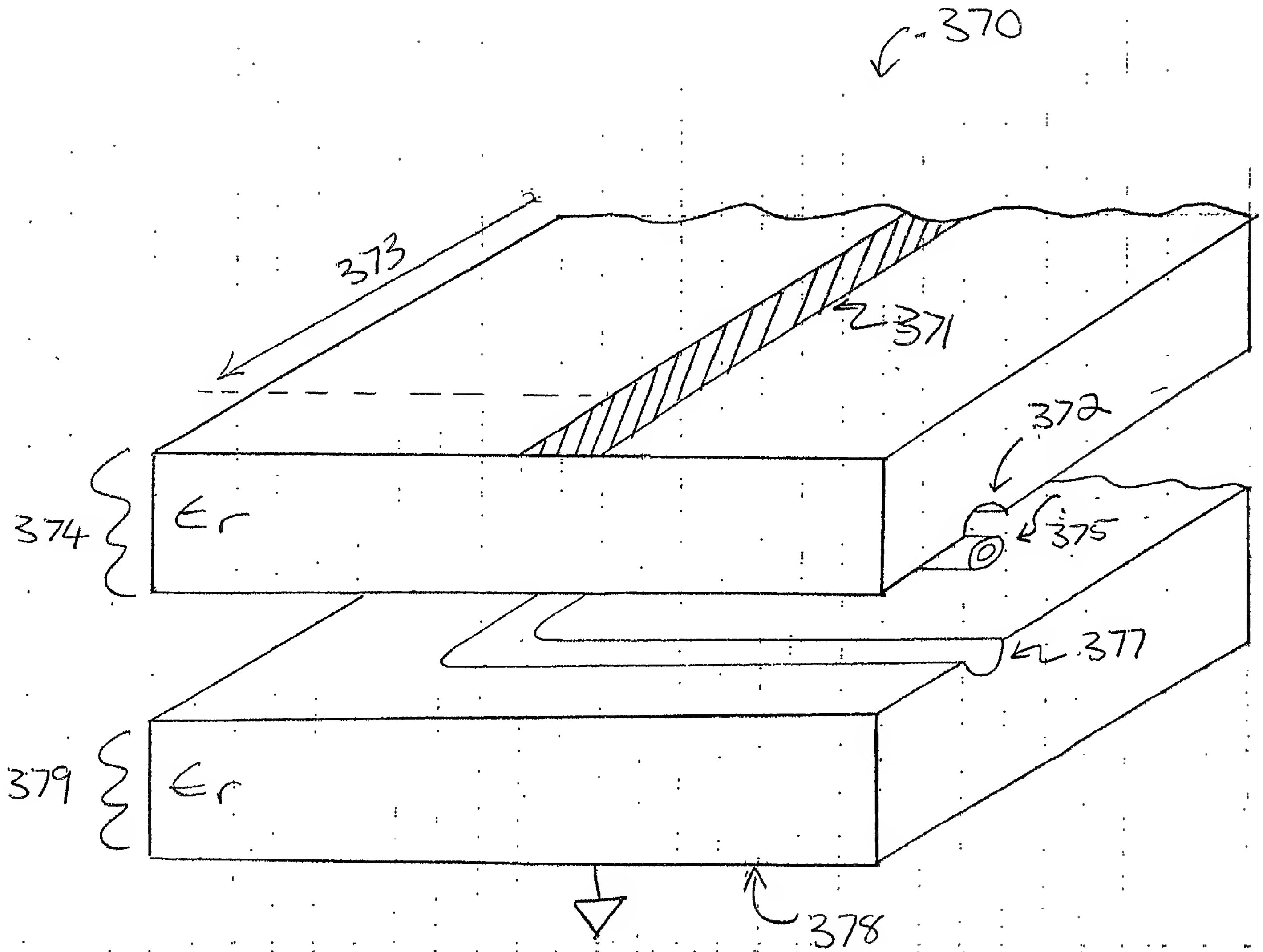


Fig 3D

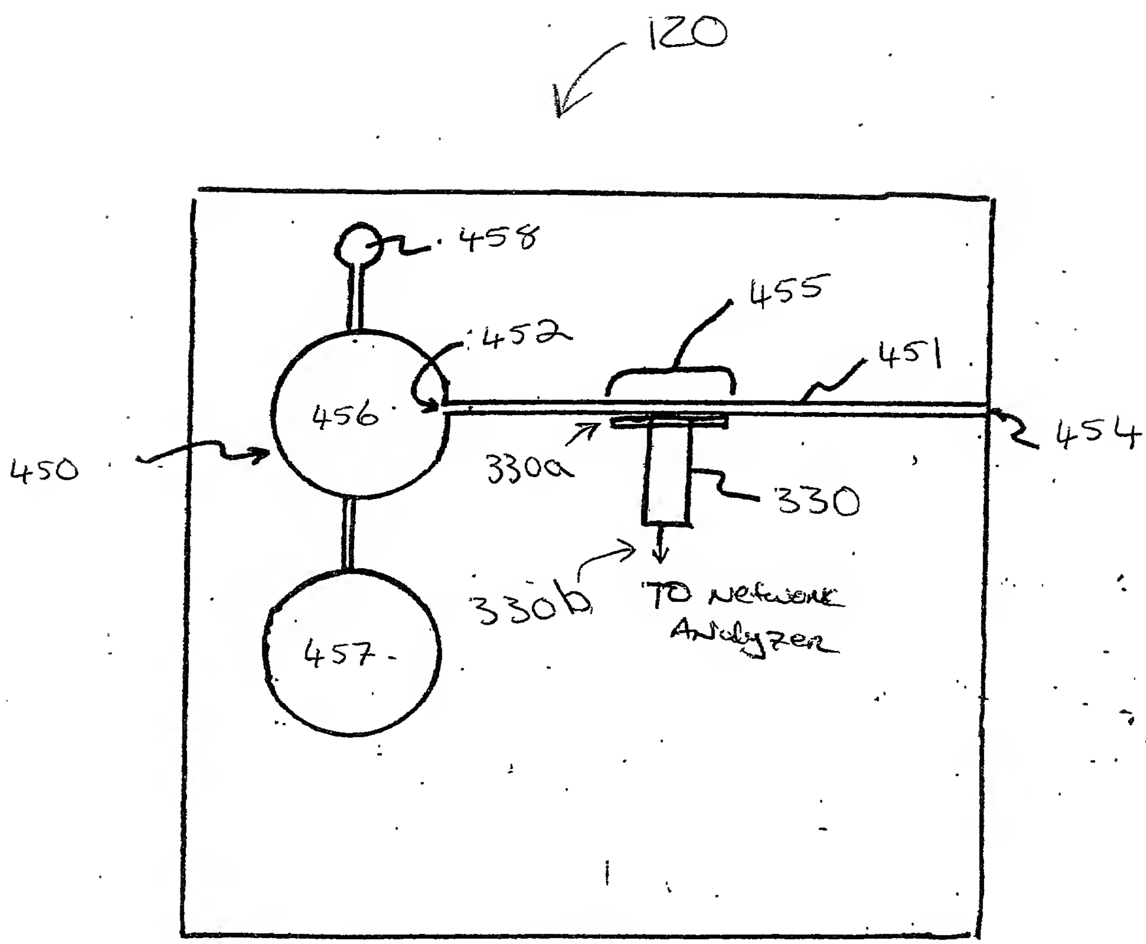
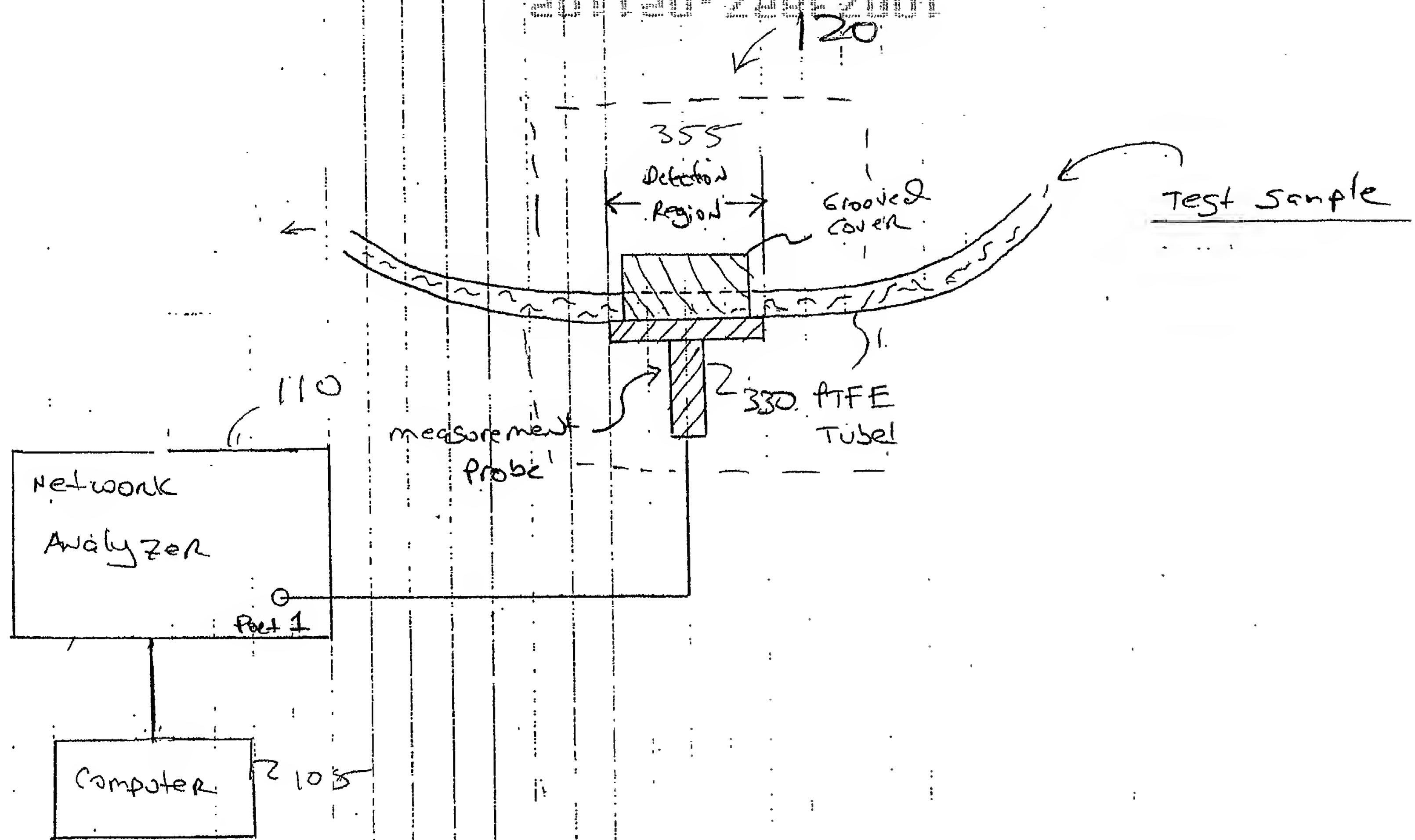

120
458
455
452
451
456
454
450
330a
330
330b
TO Network Analyzer
457

Figure 4A



120
355
Detection Region
Grooved cover
Test Sample
110
measurement Probe
330 PTFE Tube
Network Analyzer
Port 1
Computer
105

Fig 4B

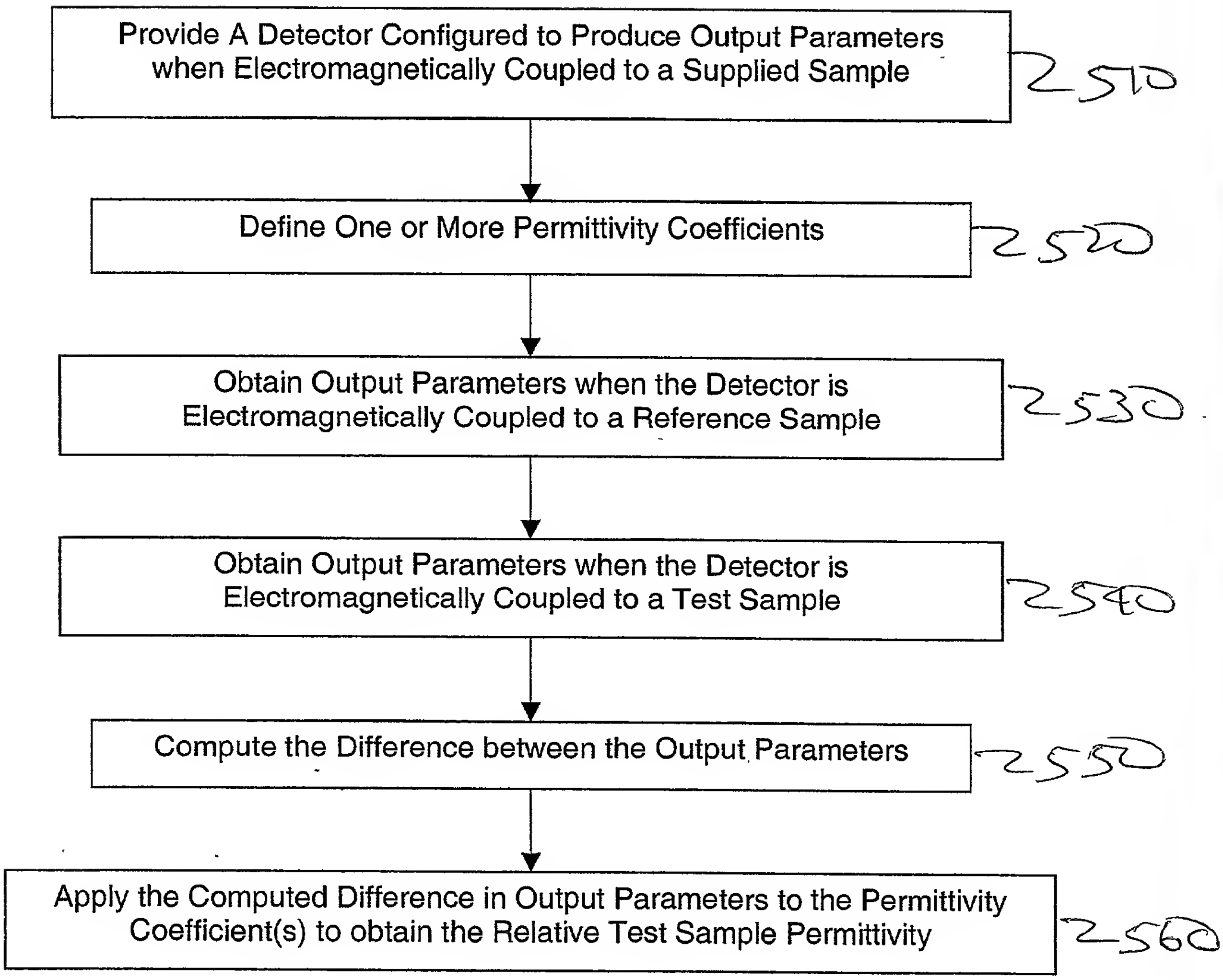

Provide A Detector Configured to Produce Output Parameters when Electromagnetically Coupled to a Supplied Sample
2510
Define One or More Permittivity Coefficients
2520
Obtain Output Parameters when the Detector is Electromagnetically Coupled to a Reference Sample
2530
Obtain Output Parameters when the Detector is Electromagnetically Coupled to a Test Sample
2540
Compute the Difference between the Output Parameters
2550
Apply the Computed Difference in Output Parameters to the Permittivity Coefficient(s) to obtain the Relative Test Sample Permittivity
2560

Fig. 5

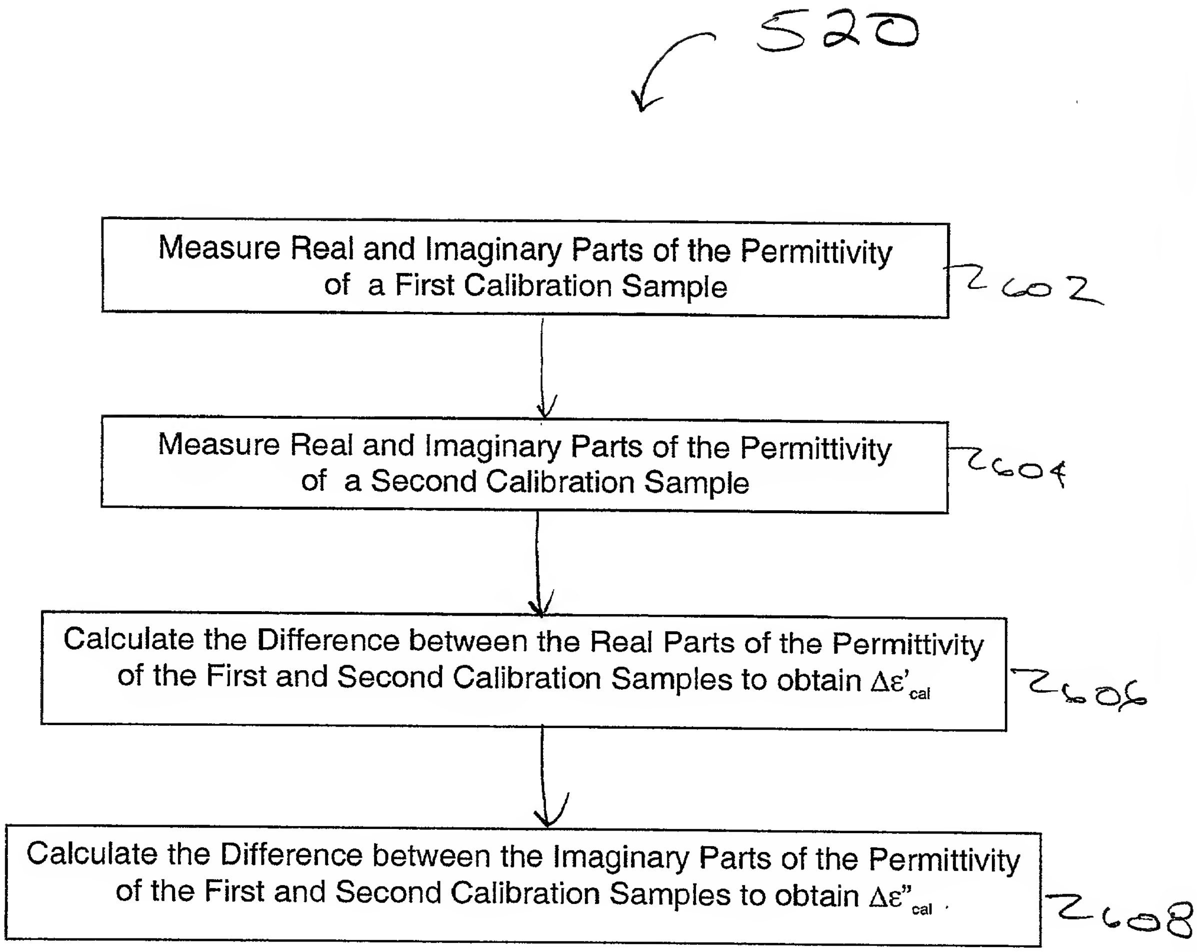

520
Measure Real and Imaginary Parts of the Permittivity of a First Calibration Sample
2602
Measure Real and Imaginary Parts of the Permittivity of a Second Calibration Sample
2604
Calculate the Difference between the Real Parts of the Permittivity of the First and Second Calibration Samples to obtain $\Delta\varepsilon'_{cal}$
2606
Calculate the Difference between the Imaginary Parts of the Permittivity of the First and Second Calibration Samples to obtain $\Delta\varepsilon''_{cal}$
2608

Fig. 6

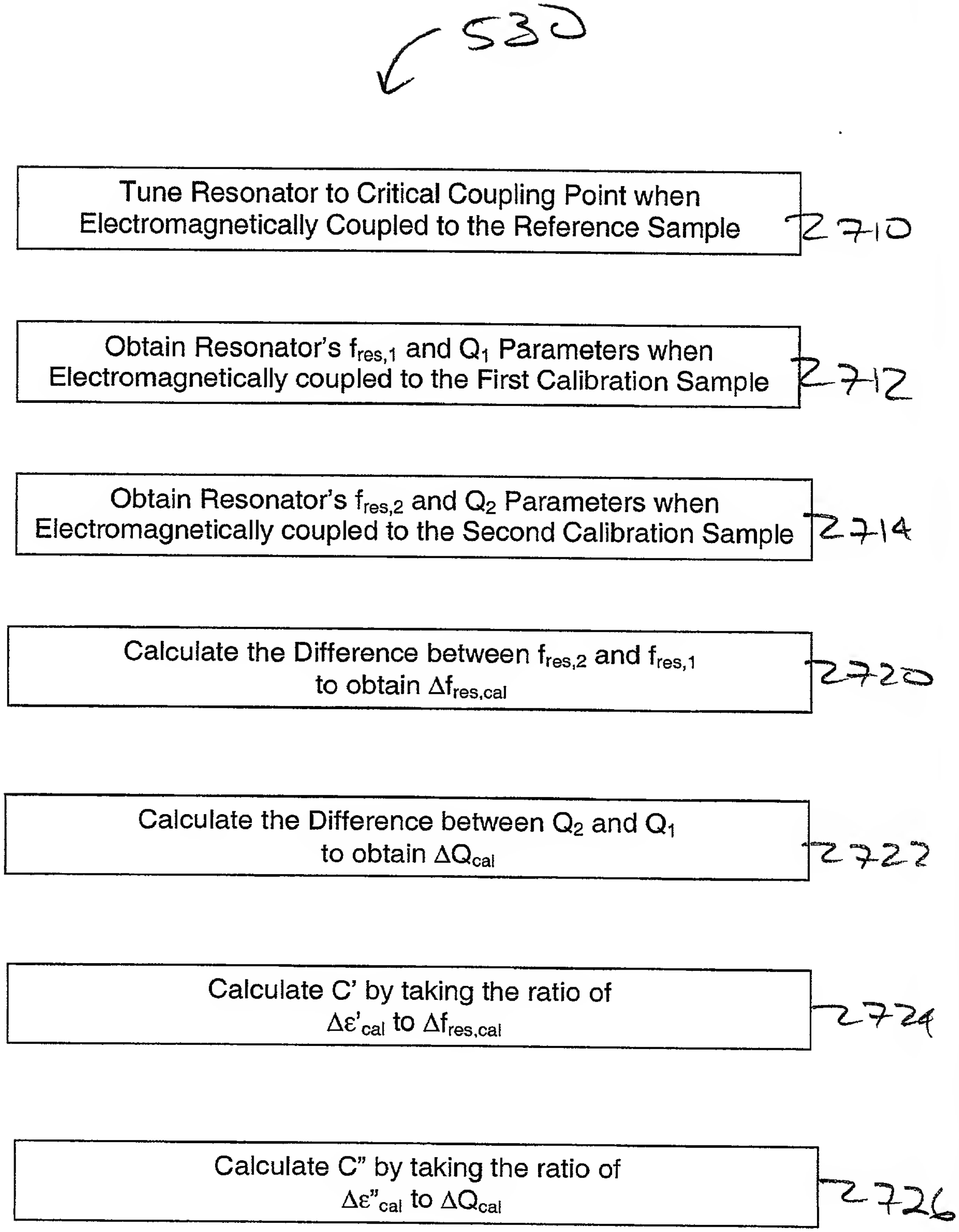

530
Tune Resonator to Critical Coupling Point when Electromagnetically Coupled to the Reference Sample
2710
Obtain Resonator's $f_{res,1}$ and Q_1 Parameters when Electromagnetically coupled to the First Calibration Sample
2712
Obtain Resonator's $f_{res,2}$ and Q_2 Parameters when Electromagnetically coupled to the Second Calibration Sample
2714
Calculate the Difference between $f_{res,2}$ and $f_{res,1}$ to obtain $\Delta f_{res,cal}$
2720
Calculate the Difference between Q_2 and Q_1 to obtain ΔQ_{cal}
2722
Calculate C' by taking the ratio of $\Delta\varepsilon'_{cal}$ to $\Delta f_{res,cal}$
2724
Calculate C" by taking the ratio of $\Delta\varepsilon''_{cal}$ to ΔQ_{cal}
2726

Fig 7A

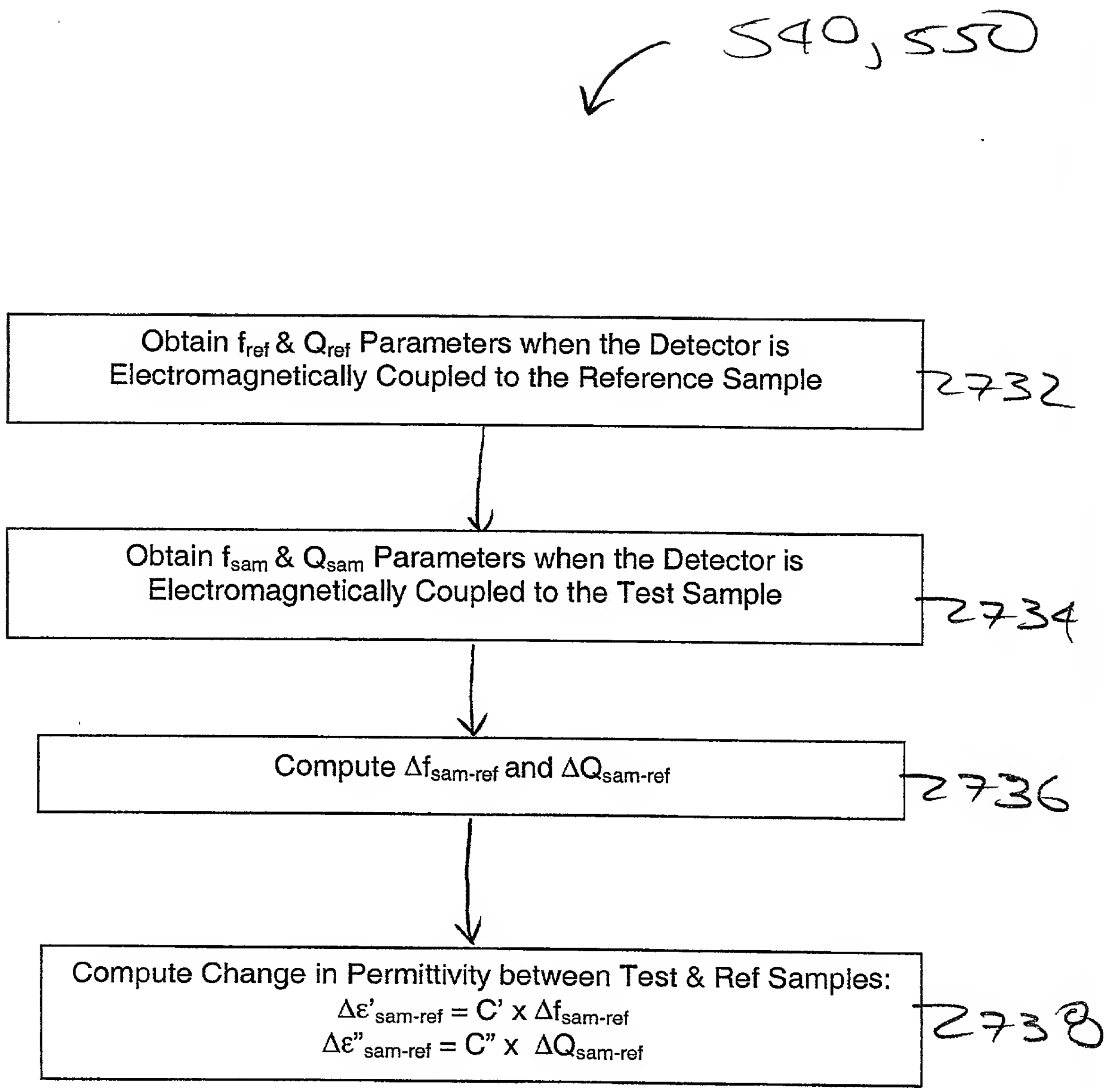

540, 550
Obtain f_{ref} & Q_{ref} Parameters when the Detector is Electromagnetically Coupled to the Reference Sample
2732
Obtain f_{sam} & Q_{sam} Parameters when the Detector is Electromagnetically Coupled to the Test Sample
2734
Compute $\Delta f_{sam\text{-}ref}$ and $\Delta Q_{sam\text{-}ref}$
2736
Compute Change in Permittivity between Test & Ref Samples:
$\Delta\varepsilon'_{sam\text{-}ref} = C' \times \Delta f_{sam\text{-}ref}$
$\Delta\varepsilon''_{sam\text{-}ref} = C'' \times \Delta Q_{sam\text{-}ref}$
2738

Fig 7B

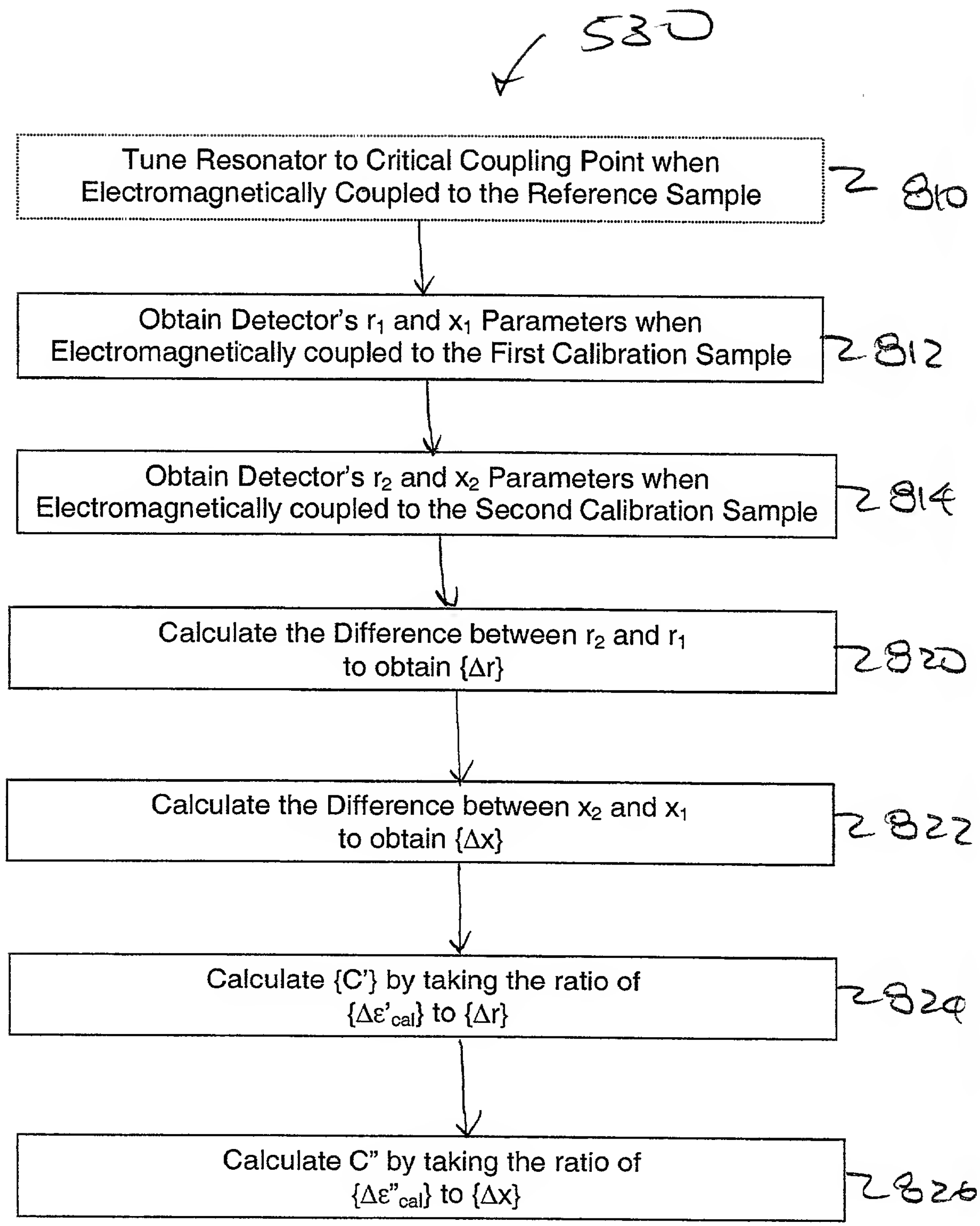

530
Tune Resonator to Critical Coupling Point when Electromagnetically Coupled to the Reference Sample
810
Obtain Detector's r_1 and x_1 Parameters when Electromagnetically coupled to the First Calibration Sample
812
Obtain Detector's r_2 and x_2 Parameters when Electromagnetically coupled to the Second Calibration Sample
814
Calculate the Difference between r_2 and r_1 to obtain $\{\Delta r\}$
820
Calculate the Difference between x_2 and x_1 to obtain $\{\Delta x\}$
822
Calculate {C'} by taking the ratio of $\{\Delta\varepsilon'_{cal}\}$ to $\{\Delta r\}$
824
Calculate C" by taking the ratio of $\{\Delta\varepsilon''_{cal}\}$ to $\{\Delta x\}$
826

Fig. 8A

540, 550

Obtain r_{ref} & x_{ref} Parameters when the Detector is Electromagnetically Coupled to the Reference Sample — 832

↓

Obtain r_{sam} & x_{sam} Parameters when the Detector is Electromagnetically Coupled to the Test Sample — 834

↓

Compute $\{\Delta x_{sam\text{-}ref}\}$ and $\{\Delta r_{sam\text{-}ref}\}$ — 836

↓

Compute Change in Permittivity between Test & Ref Samples: — 838

$$\{\Delta\varepsilon'_{sam\text{-}ref}\} = \{C'\} \times \{\Delta r_{sam\text{-}ref}\}$$

$$\{\Delta\varepsilon''_{sam\text{-}ref}\} = \{C''\} \times \{\Delta x_{sam\text{-}ref}\}$$

Fig. 8B

530

Obtain Detector's I_1 and Q_1 Parameterswhen the Detector is Electromagnetically coupled to the First Calibration Sample 2912

Obtain Detector's I_2 and Q_2 Parameterswhen the Detector is Electromagnetically coupled to the Second Calibration Sample 2914

Compute $\{\Delta I_{cal}\}$ and $\{\Delta Q_{cal}\}$ 2916

Calculate $\{C'\}$ by taking the ratio of $\{\Delta\varepsilon'_{cal}\}$ to $\{\Delta I_{cal}\}$ 2920

Calculate $\{C''\}$ by taking the ratio of $\{\Delta\varepsilon''_{cal}\}$ to $\{\Delta Q_{cal}\}$ 2922

Fig. 9A

540, 550

Obtain I_{ref} and Q_{ref} when the Detector is Electromagnetically coupled to the Reference Sample 2932

Obtain I_{sam} and Q_{sam} when the Detector is Electromagnetically coupled to the Test Sample 2934

Compute $\{\Delta I_{sam\text{-}ref}\}$ and $\{\Delta Q_{sam\text{-}ref}\}$ 2936

Compute Change in Permittivity between Test & Ref Samples: 2938

$$\{\Delta\varepsilon'_{sam\text{-}ref}\} = \{C'\} \times \{\Delta I_{sam\text{-}ref}\}$$

$$\{\Delta\varepsilon''_{sam\text{-}ref}\} = \{C''\} \times \{\Delta Q_{sam\text{-}ref}\}$$

Fig. 9B

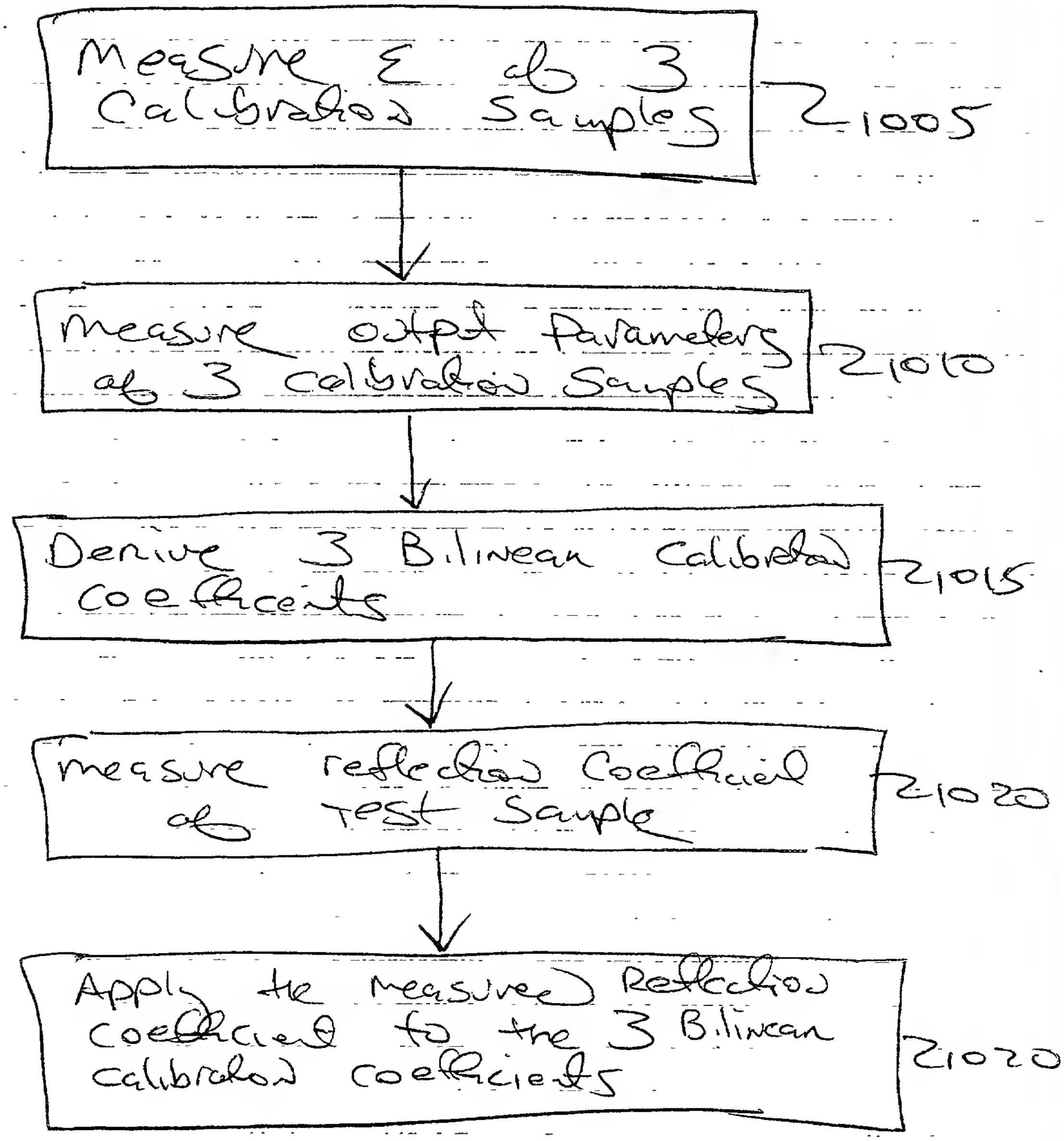

Measure ε of 3 Calibration Samples
1005
measure output Parameters of 3 calibration Samples
1010
Derive 3 Bilinear Calibration coefficients
1015
measure reflection Coefficient of Test Sample
1020
Apply the measured Reflection coefficient to the 3 Bilinear calibration coefficients
1020

Fig. 10

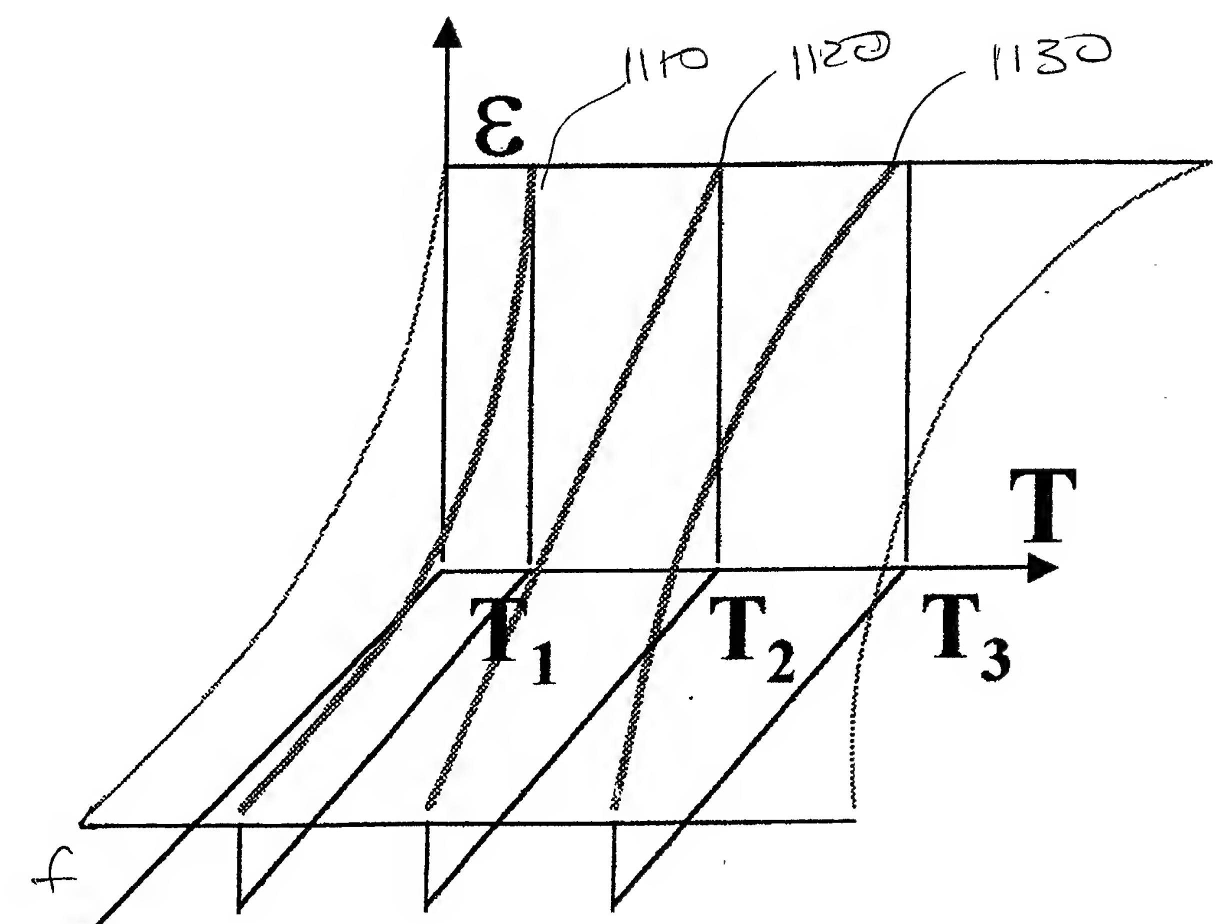


Fig 11

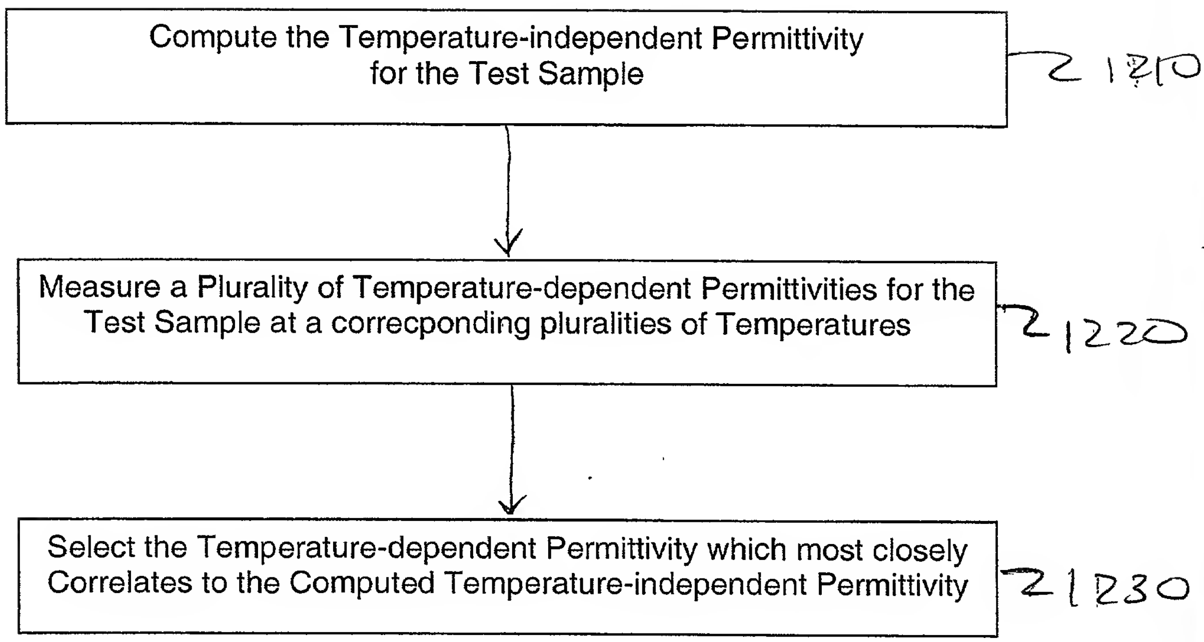

Compute the Temperature-independent Permittivity for the Test Sample
1210
Measure a Plurality of Temperature-dependent Permittivities for the Test Sample at a correcponding pluralities of Temperatures
1220
Select the Temperature-dependent Permittivity which most closely Correlates to the Computed Temperature-independent Permittivity
1230

Fig 12A

1220

Use Dielectric Probe to Measure the Reference Sample Permittivity (Re and Im parts) at Temperatures $t_0, t_1, t_2 \ldots t_n$ 1222

Use Dielectric Probe to Measure the Test Sample Permittivity (Re and Im parts) at Temperatures $t_0, t_1, t_2 \ldots t_n$ 1224

Compute:
$\Delta\varepsilon'(t_0), \Delta\varepsilon'(t_1), \Delta\varepsilon'(t_2), \ldots \Delta\varepsilon'(t_n)$ and
$\Delta\varepsilon''(t_0), \Delta\varepsilon''(t_1), \Delta\varepsilon''(t_2), \ldots \Delta\varepsilon''(t_n)$ 1226

Fig. 12B

1230

Compute:
$\mathrm{Abs}[\Delta\varepsilon' - \Delta\varepsilon'(t_i)]_{ti = \{t0,\, t1,\, t2,\, \ldots\, tn\}}$ and
$\mathrm{Abs}[\Delta\varepsilon'' - \Delta\varepsilon''(t_i)]_{ti = \{t0,\, t1,\, t2,\, \ldots\, tn\}}$ 1232

The ~~Temperature-dependent~~ Permittivity is the $\Delta\varepsilon'(t_i)$ and $\Delta\varepsilon''(t_i)$ which produces Absolute Values closest to zero. 1234

Fig. 12C